# Forage for optimum resilience & growth

## A Farm Net Zero Field lab

## Final report

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## Summary

### Take home messages

While there weren't clear and obvious benefits to worm burden and growth rates at all farms, some triallists did find clear differences relating to growth rates on different covers. There were also clear soil health improvements and carbon footprint reductions associated with different covers Where daily liveweight gain was compared on a per hectare basis two farms found a clear benefit from the chicory rich mix compared to both the herbal ley and the grass control.

### Context

Weaning shock causes physiological stress and can cause a sudden increase in worm burden in lambs. This effect can be offset by first and secondary metabolites[1] and also through enhanced forage protein content (Bebbington, 2023, pers comm). Forage legumes are central to providing crude protein, and white clover is the commonly used species for this in leys but not in cover crops. Therefore, in contrast to a brassica-based cover crop, a protein and secondary metabolite rich mixture will potentially reduce worm burden associated with weaning shock.

### Trial design

Across 3 farms, fields were split into four plots: forage rape, a chicory-plantain-crimson clover mix, a herbal ley mix and a grass/clover control. Covers were grazed at weaning. Ahead of weaning, animals were weighed and faecal egg counts carried out. A soil health assessment was also carried out ahead of grazing. Post grazing, the fecal egg counts, weighing and soil health assessments were repeated.

### Findings

There was little difference in worm egg counts between treatments across the farms, although there was some variation within farms. Similarly, there was no significant difference in daily liveweight gain across the farms but there was significant differences on a farm-by-farm basis. At Trefranck and Higher Thornton the chicory rich mix out performed the grass control and herbal ley, whereas at Higher Coombe the herbal ley was the best performer.


[1] Metabolites are chemical compounds produced by organisms when functionaing normally. Primary metabolites are essential for normal metabolic processes including the growth, development, and reproduction of cells. Secondary metabolites are not necessary for basic metabolic processes but play important roles in the organism's interaction with its environment.

There was a clear, although small, uplift in soil health under the chicory rich mix and the herbal leys (all farms had good baseline soil health). One clear finding relating to soil health was that where one grass control was direct drilled (compared to using cultivation for establishment) there was a clear advantage in both establishment and total forage produced across the season for the cultivated field, with a corresponding benefit to soil health.

Where daily liveweight gain (DLWG) was higher this translated into a much lower number of days to finish and a correspondingly lower carbon footprint per 100 lambs finished.

**Recommendations & next steps**

As is often the case the trial threw up more questions than it did answers. If repeated the trial would benefit from a more rigorous faecal egg count methodology to better understand variations in worm burden. There is also a number of questions around establishment techniques for the forage mixes, also adapting time of establishment to better suit each individual farm and the prevailing conditions.

Understanding your soil conditions ahead of establishment is important, if there is evidence of compaction within the profile then a cultivation to address this is worth the better establishment this will provide as opposed to attempting to direct drill.

Substituting red clover for crimson clover is a good choice where leys are required to last for 2 or more years.

**Useful resources:**

**Anthelmintic effects of forage chicory (Cichorium intybus) against free-living and**

**parasitic stages of Cooperia oncophora** - Pena-Espinoza, Miguel Angel; Williams, Andrew R. ; Thamsborg, Stig M.; Simonsen, Henrik Toft; Enemark, Heidi L.

DLF Seeds UK - https://www.dlf.co.uk/

## Main report

### 1 Field lab aims

The overarching objective was to identify diverse leys and cover crops which improve the health and resilience of lamb production.

The farmers' motivation was to increase lamb welfare, reduce the need for anthelmintics and enhance growth rate. The chicory/plantain leys also have the potential to improve soil health compared to simple brassica cover crops or ryegrass white clover leys.

### 2 Background

This field lab was part -funded by IF and part by the Farm Net Zero, Cornwall project, funded by the National Lottery Community fund. Three farmers– Matt Smith (Trefranck Farm), Chris Berry (Higher Thornton Farm), Mark Hayman (Higher Coombe Farm), designed this field lab, with support from the Farm Carbon Toolkit and additional sponsorship from DLF Seeds Ltd.

The motivation for the trial was to try and discover if it is possible to increase lamb welfare, reduce the use of anthelmintics and achieve a corresponding increase in growth rates from a different forage mix. There was also the possibility of seeing improved soil health where the chicory rich/herbal ley mixes were employed due to the well documented benefits of these diverse mixes such as increased rooting depth and benefits to soil biology. In addition, the combination of increased growth rates (and reduced days to finish) and improved soil health should result in a reduction in carbon footprint for the farms through a reduction in the number of days on holding for the lambs and a potential increase in soil organic carbon.

### 3 Methodology and data collection

Across the three farms each trial mix was established in the spring, either split across one field, half and half, or across multiple fields. Trefranck Farm did not establish the forage rape cover. The aim was that leys would be established in time for grazing at weaning.

Prior to weaning the lambs were all weighed and split into groups for each grazing mix. At the same time faecal samples were collected for each group, with a minimum of four replicates per group, and these sent for worm egg counts. Condition scoring was carried out to quantify welfare, and the use of medication (e.g. spot worm treatment) where required. Lambs were grazed using a strip-based system.

Prior to grazing, soil health assessments were carried out across all trial mixes, with three replicates per treatment. The assessment included VESS (Visual Assessment of Soil Structure), infiltration, earthworm counts and aggregate stability.

Statistical analysis was carried out to determine the potential significance of the research findings.

**Seed Mixtures**

- **Brassica** – Mainstar Forage Rape @ 5kg/ha

- **Temporary ley control** – @ 13-15kg/ha consisting of; White clover blend (5%); Lofa ryegrass (14%); Tetragraze hybrid rye grass (20%); Agaska intermediate rye grass (14%); Nolwen intermediate rye grass (15%); Toddington late rye grass (15%); Nashota late rye grass (17%)

- **Chicory/plantain/crimson clover mix** - @9kg/ha consisting of; Choice chicory (40%); Ecotain (40%); Crimson clover (20%)

- **Herbal ley** - @ 9kg/ha consisting of; Nifty intermediate perennial ryegrass (13%); Nashota late ryegrass (15%); Winnetou timothy (7%); Laura meadow fescue (10%); Red clover blend (10%), Lucerne (2%); White clover duel purpose mix (5%); Alsike clover (5%); Leo birdsfoot trefoil (3%); Choice chicory (8%); Ecotain plantain (10%); Yarrow (1%); Sheep's burnet (0.5%); Sheep's parsley (0.5%)

## 4 Results and discussions

### Daily liveweight gain

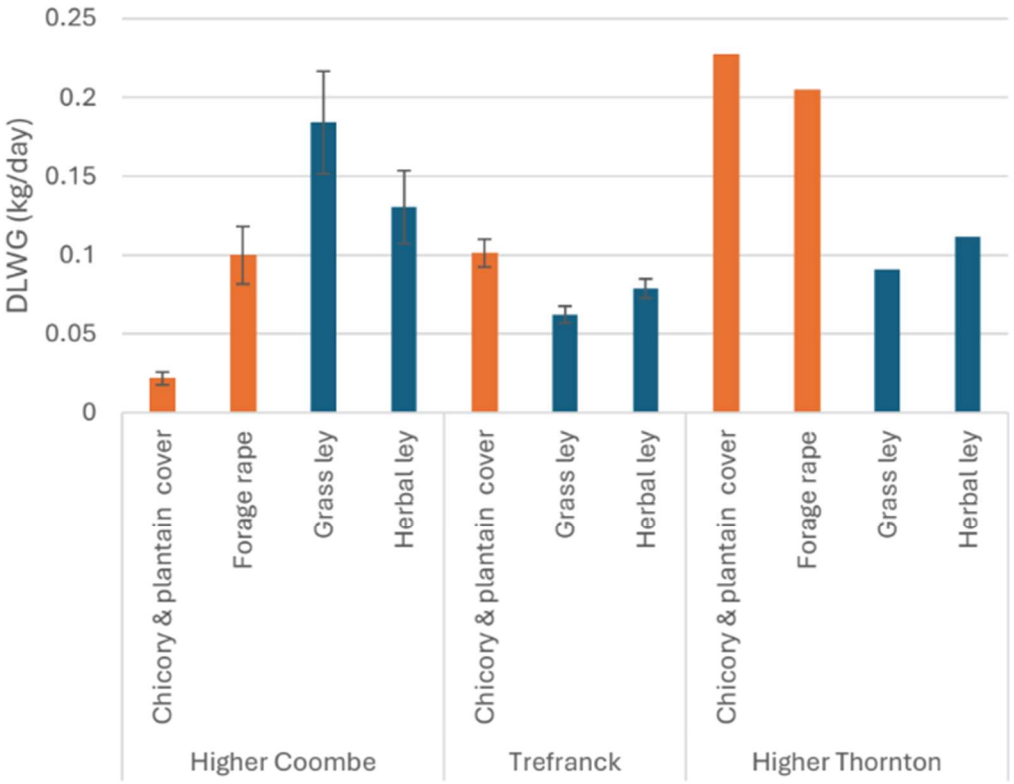



**Figure 1. Average Daily Live Weight (DLWG) of ewe lambs at farms Higher Coombe, Trefranck and Higher Thornton.**

**Error bars indicate standard error with exception of Higher Thornton where one data value for the whole flock is given.**

**The cover crop trial is indicated by the orange bars (no forage rape was grown at Trefranck) and the grass ley is indicated by the blue bars.**

If just the average DLWG values are analysed for all farms and treatments without including individual lamb weight gain, there is no significant difference in treatment (P = 0.899). If this is restricted to just herbal leys compared to grass leys there is no significant difference in DLWG (P = 0.896).

For the grass ley, there was no significant difference in DLWG between the herbal ley and the grass and white clover ley (P = 0.737) overall. However, there was a farm effect such that lambs performed significantly better on herbal leys at Trefranck compared to Higher Coombe, but the inverse was true at Higher Coombe where lambs performed better on grass leys (P = 0.028).

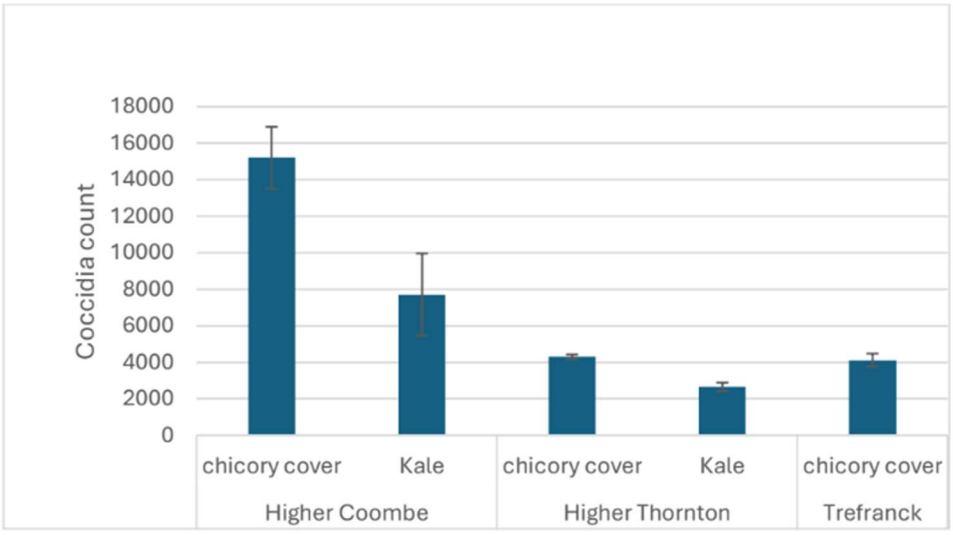
Where daily liveweight gain was compared on a per hectare basis for both Trefranck and Higher Thornton there was a clear benefit from the chicory rich mix compared to both the herbal ley and the grass control (forage rape also performed well at Higher Thornton)

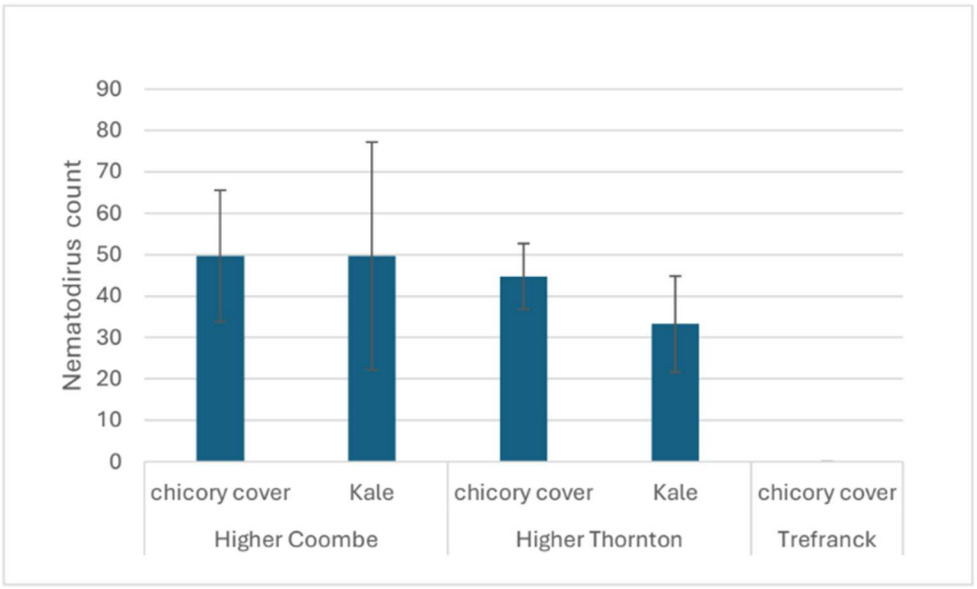
| Farm | Forage rape | Plantain/Chicory | Herbal Ley | Grass |
|---|---|---|---|---|
| **Trefranck** | **—** | **228** | **178** | **135** |
| **Higher Thornton** | **185.6** | **222** | **61.6** | **54** |

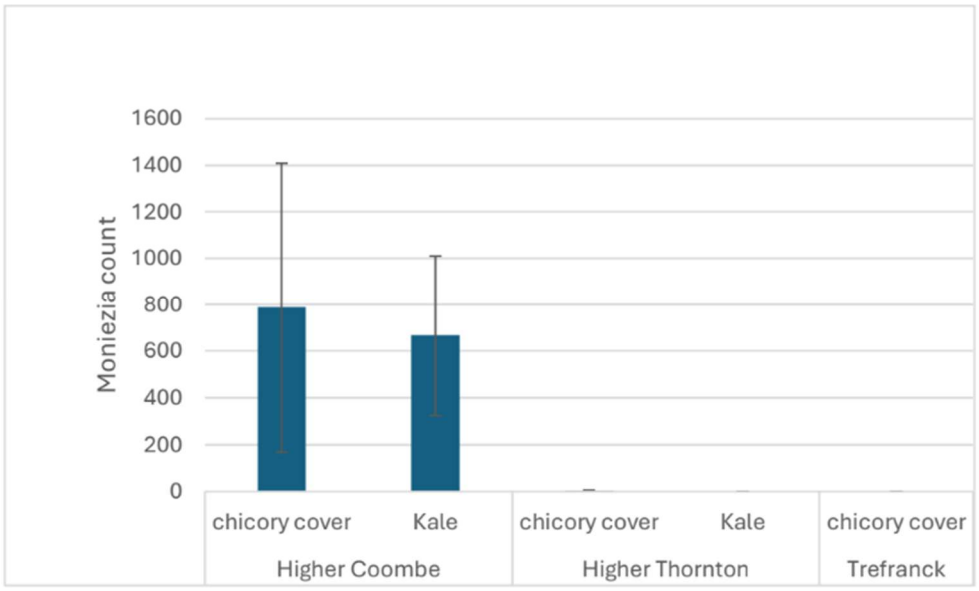
**Figure 2: Daily liveweight gain in kilos on a per hectare basis**

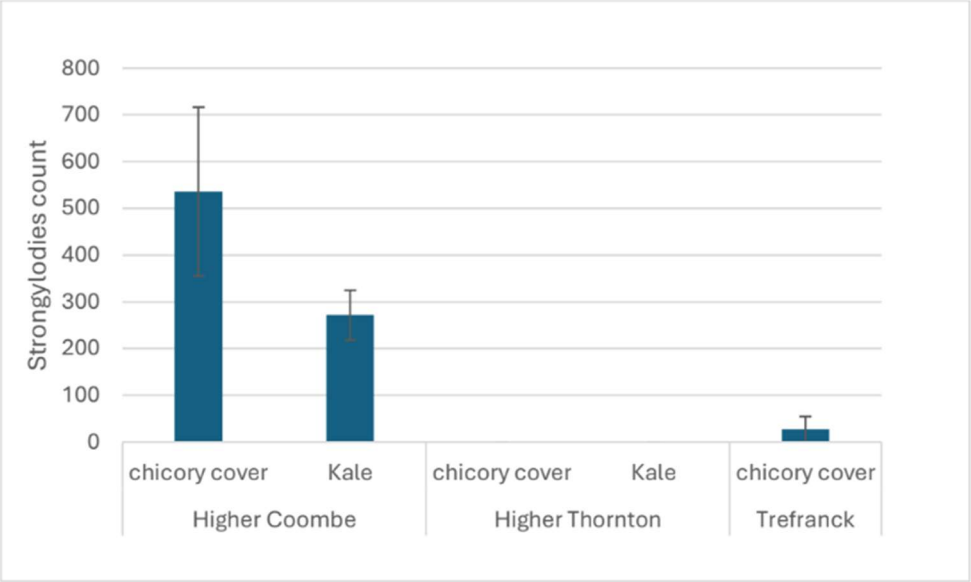
## Worm egg counts

**Figure 3: Final lamb Faecal Egg counts (FEC) for individual worm genera Coccidia spp, Nematodirus spp, Moniezia spp, and Strongyloidies spp. For the cover crops kale and the chicory mixture on farms Higher Coombe, Higher Thornton and Trefranck. Error bars indicate standard error for 4 replicate assessments. Zero values indicate an absence of the worm genus at that farm site.**




Nematodirus count
90
80
70
60
50
40
30
20
10
0
chicory cover
Kale
chicory cover
Kale
chicory cover
Higher Coombe
Higher Thornton
Trefranck


Moniezia count
1600
1400
1200
1000
800
600
400
200
0
chicory cover
Kale
chicory cover
Kale
chicory cover
Higher Coombe
Higher Thornton
Trefranck




Coccida spp. was significantly higher on the chicory cover crop (P = 0.01) with a predicted mean over double the burden with chicory (7731 compared to 3671 per count, each count consisted of a unit volume ranging from 1.26 to 1.35ml)). There was no significant effect of treatment on Moniezia (P= 0.949), Nematodirius (P = 0.79), Strongyles (P= 0.336), or Strongyloidies (P =0.291).

For the ley treatment comparison, there was no significant effect on Coccidia (P=0.325), Stronglyes (P=0.095),Strongyloidies (P=0.211) or Moniezia (P=0.435) but Nematodirius was higher on the herbal ley (P=0.038).

There was a clear significant effect of farm on Coccidia (P=0.03), Nematodirius (p=0.27), and Strongyloidies (p=<0.001) and borderline effect with Strongyles (P=0.052). If farm effect included in the fixed model (REML) , herbal leys had higher counts of nematodirius (P=0.02) and Stronglyes (borderline P = 0.052) but Strongloidies (P=0.013) was significantly lower with the herbal leys.

FEC counts were completed for the beginning and at the end of the trial. The FEC counts were per flock, and not allocated to a particular treatment with exception to Higher Coombe. For Higher Coombe, there is data on entry and exits FEC counts. If this data is analysed separately, to assess change in worm burden, there was no significant change in Coccidia (P=0.171), Moniezia (P=0.444), Nematodirius (P0.249), Strongyles (P=0.174), but for Strongloidies, kales had significantly less worms (P=0.05) of this genus compared to the chicory cover.

The reported anthelmintic benefits of chicory mixtures were not evident in this trial through the faecal egg counts. However there was no significant difference in daily live weight gain, that is herbal leys were no worse than grass clover leys for lamb growth. So although herbal leys perform as well as standard grass leys, they do offer the additional reported benefits of an uplift in carbon sequestration and soil health benefits.

There is a clear farm effect. Different worm burdens existed between farms, not only in total number but also the genera present. FEC counts were a poor proxy to DLWG; significant differences in worm burden between treatments did not in most cases translate to differences in DLWG with exception to the kale cover at Higher Thornton. At this farm a low burden of Strongloidies on kale could potentially be linked to the higher DLWG on this cover crop.

The workshop discussion highlighted the need for a greater resolution of worm identification to identify those which may be of negligible impact on health as opposed to those which require immediate action.

It is also important to note here the concept of resilience to worms. Resistance to anthelmintic drenches (wormers) is an increasing challenge and coupled with the environmental impact of these treatments highlights the need for a different approach. Resilience (or tolerance) to parasitic worms is where an animal continues to survive and thrive despite a high burden of these worms. These animals are able to continue to breed and grow without the need to resort to treatment, targeting any treatment to those animals that genuinely need it. Resilience differs to resistance, where an animal produces an immune response to a parasite, in that parasitic worms can become in turn resistant to this immune response, which in combination with resistance to worm treatments can result in so-called 'super worms'. Understanding the concept of resilience requires us to better interpret any data we are collecting on farm. In this situation it is preferable to combine information from FECs and DLWG to make decisions on which animals to treat for worms rather than relying on FECs in isolation.

**Soil health assessments**

All of the participant farms had excellent baseline soil health and there was some uplift across all treatments, although this was most pronounced in the herbal ley and chicory rich covers.

Anecdotally this uplift in soil health was again most pronounced in both the covers with higher levels of species diversity with deeper colouring of the soil and that healthy soil smell more evident in these covers, with better examples of root sheaths which indicate high levels of biological activity in the soil.

**Figure 4: Example of a soil root sheath at Trefranck Farm in the herbal ley**

**Figure 5: Example of a deep tap root on a chicory plant after ~6-7 weeks growth at Higher Thornton**

| | VESS top pre-grazing | VESS top post-grazing | VESS bottom pre-grazing | VESS bottom post-grazing | Earthworms pre-grazing | Earthworms post-grazing |
|---|---|---|---|---|---|---|
| **Higher Thornton Grass** | 1.7 | 1.7 | 2.2 | 2.0 | 4.3 | 6.3 |
| **Higher Thornton Kale** | 2.0 | 2.0 | 2.7 | 2.5 | 3.0 | 6.0 |
| **Higher Thornton Chicory Rich** | 1.5 | 1.5 | 2.5 | 2.2 | 2.7 | 9.0 |
| **Higher Thornton Herbal Ley** | 2.0 | 2.0 | 2.5 | 2.3 | 2.3 | 6.6 |
| **Higher Coombe Grass** | 2.2 | 2.0 | 3.2 | 3.2 | 3.0 | 3.0 |
| **Higher Coombe Kale** | 2.3 | 2.0 | 3.0 | 3.0 | 1.7 | 1.8 |
| **Higher Coombe Chicory Rich** | 2.0 | 1.8 | 3.0 | 2.8 | 5.0 | 8.0 |
| **Higher Coombe Herbal Ley** | 2.0 | 1.8 | 3.0 | 2.7 | 3.7 | 5.0 |
| **Trefranck Grass** | 1.5 | 1.5 | 2.0 | 2.0 | 7.7 | 9.3 |
| **Trefranck Chicory rich** | 1.7 | 1.5 | 2.0 | 2.0 | 7.7 | 10.3 |
| **Trefranck Herbal Ley** | 1.7 | 1.5 | 2.0 | 2.0 | 4.3 | 6.3 |

**Figure 6: Summary of soil health assessments at both pre and post grazing**

An interesting additional finding at Trefranck Farm surrounded the establishment methods used. On the grass control two establishment methods were utilised, one field was direct drilled and one field was cultivated, involving deep ripping and discing.

There was significantly poorer establishment where the grass was direct drilled compared to where cultivation was used. There was consequently a higher number of undesirable species such as docks and thistles.

**Figure 7: comparison between the direct drilled grass control (left) and the grass established with cultivation (right)**

There were also significant differences in soil health metrics between the two fields with a level of surface compaction in the direct drilled field and low earthworm numbers, albeit those that were present were adults.

Post-establishment the cultivated field did not show any evidence of compaction with a uniform and consistent, loose soil structure through the profile, as expected after a cultivation event. The surface compaction in the direct drilled field would have been the sole reason for the poor establishment and highlights the need for assessing your soil conditions ahead of drilling to ensure the best establishment method is used to maximise the potential of your reseed .

There were no earthworms although there was the presence of earthworm eggs. When the post-grazing soil health assessments were carried out the direct drilled field showed no difference in soil health metrics whereas the cultivate field showed excellent soil structure, increased aggregation from the pre-grazing assessment and a good number of earthworms as well as smelling in excellent health.

**Figure 8: Difference in soil health metrics between direct drilled grass (top) and cultivated (bottom)**

**Carbon Impact**

The quicker finishing time of any livestock can have a positive impact on reducing emissions for a farm, resulting from reduced enteric methane emissions due to each animal being on farm for comparatively shorter periods. For every day that an animal is on farm it is releasing methane through the process of digesting plant materials it has eaten, a process unique to ruminants such as cattle and sheep and one which garners significant attention when we discuss reducing emissions form agriculture. Therefore if we can provide a diet for livestock that allows them to reach slaughter weight as quickly as possible we are then reducing the number of days that animal is on farm emitting methane, thus reducing the emissions of the farm as a whole.

This was amply demonstrated at Higher Thornton Farm where the higher DLWG for the lambs on the chicory rich mix resulted in a significantly reduced number of days to finish. On average it took lambs on the grass control 144 days to reach finishing weight,, whereas for the lambs on the chicory rich mix it took 56.5 days. This resulted in significantly reduced

greenhouse gas emissions (measured in tonnes of carbon dioxide equivalent) , with a resulting 61% reduction in carbon dioxide equivalent emissions per 100 lambs.

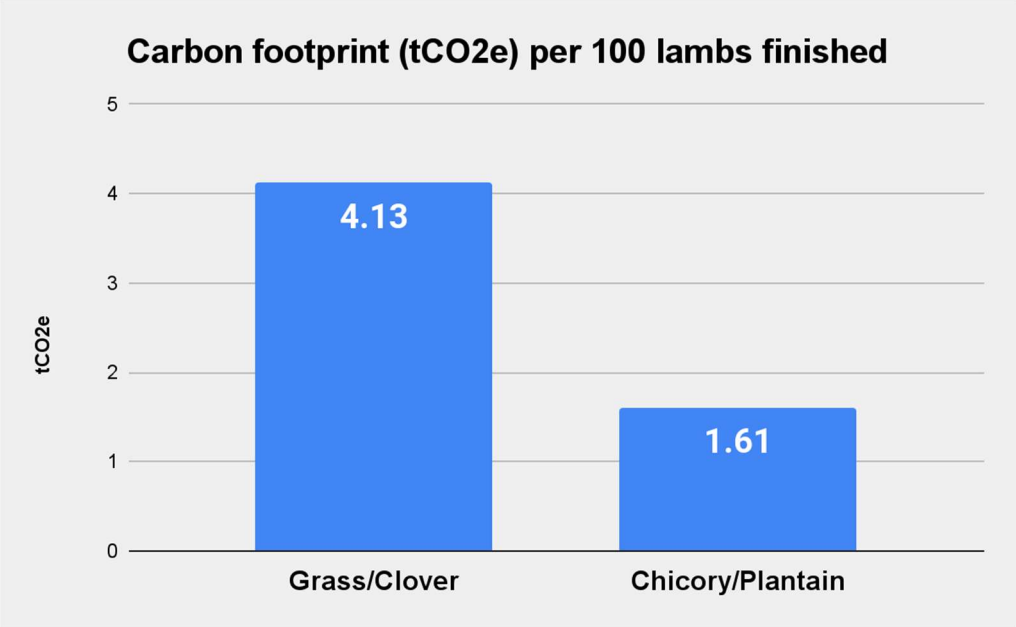



**Figure 9: comparison between tonnes of CO2e per 100 lambs on the grass control and the chicory rich mix**

**Conclusions**

- There were not clear and obvious benefits to worm burden and growth rates across all farms
- There were clear improved growth rates between treatments on individual farms with the chicory rich mix outperforming the other treatments at Trefranck and Higher Thornton and the herbal ley the best performer at Higher Coombe
- There were clear soil health improvements where the diversity of plant species were higher, the herbal ley and the chicory rich mixes
- If trials were to be repeated a higher resolution method of monitoring worm numbers would be beneficial to better understand variations from each treatment
- There was the observation that where there are soil structure/compaction issues it is worth addressing these issues to ensure optimum establishment of any re-seed, soil health will recover and often be better than before
- Where growth rates were higher the reduced time to finish, and thus time on holding, resulted in a significant drop in emissions from livestock.

**Tips and recommendations**

- Before establishment of any forage crop or re-seed dig holes to understand if you have structural/compaction issues and use this information to make informed decisions as to which establishment method is best
- For the chicory rich mixture if you want a ley to last 2+ years then consider switching the crimson clover with red clover
- Adjust establishment time to what best suits your farm, your rotation and the prevailing climatic condition

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